Roadway Intersection Inventory and Remote Sensing

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GIS-T 2001

April 11, 2001

USDOT Remote Sensing Initiative

- NCRST-Infrastructure
  University of California, Santa Barbara (lead), University of Wisconsin, University of Florida, Iowa State University
- Sponsored by
  - USDOT
  - RSPA
- NASA
- Joint endeavor with Iowa DOT

The Problem/Opportunity

- DOT use of spatial data
  - Planning
  - Infrastructure Management
  - Traffic engineering
  - Safety, many others
- Inventory of large systems costly
  - e.g., 110,000 miles of road in Iowa

The Problem/Opportunity

- Current Inventory Collection Methods
  - Labor intensive
  - Time consuming
  - Disruptive
  - Dangerous

The Problem/Opportunity

- Collect transportation inventories through remote sensing
- Improve existing procedures
- Exploit new technologies
- Extract data which was previously difficult and costly to obtain

Remote Sensing

- "the science of deriving information about an object from measurements made at a distance from the object without making actual contact" Campbell, J. *Introduction to Remote Sensing, Second Edition*.
- Three types
  - 1) space based or satellite
  - 2) airplane based or aerial
  - 3) in-situ or video/magnetic

Research Objective

- Can remote sensing be used to collect infrastructure inventory elements?
- What accuracy is possible/necessary?

Research Approach

- Identify common inventory features
- Identify existing data collection methods
- Use aerial photos to extract inventory features
- Performance measures
- Define resolution requirements
- Recommendations

Identify Common Inventory Features

- HPMS requirements
- Additional elements (Iowa DOT)

- Number of signals at intersections
- Number of stop signs at intersections
- Type of area road passes through (residential, commercial, etc)
- Number of business entrances
- Number of private entrances
- Railroad crossings
- Intersection through width

Required HPMS Features

- Section Length
- Number of Through Lanes
- Surface/Pavement Type
- Lane Width
- Access Control
- Median Type
- Median Width
- Peak Parking
- Shoulder Type
- Shoulder Width
  - Right and Left
- Number of Right/Left Turn Lanes
- Number of Signalized Intersections
- Number of Stop Intersections
- Number of Other Intersections

Inventory Features Collected

- Thru Lane Characteristics
  - Number, width
- Turning Lane Characteristics
  - Presence, type, number, **width, length**
- Shoulder Characteristics
  - Presence, width
- Parking
  - **type**
- Medians
  - Presence, type, width

- Access Features
  - Number, business, private
- Pavement type
- **Signal Structure/Type**
  - **Mast, post, strung**
- **Intersection Location**
  - **Commercial, residential, etc.**
- **Pavement Markings**
  - **Crosswalks, stop bars, pedestrian islands**

Data Collection Methods

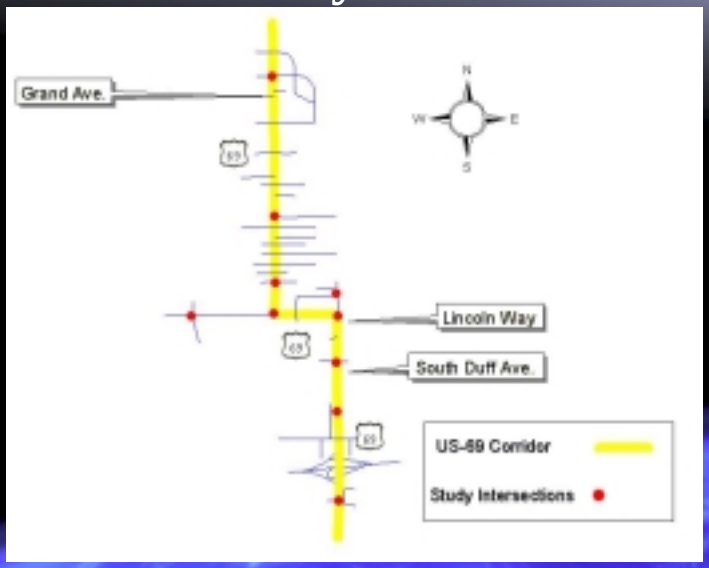
- Field data collection
  - GPS
  - Traditional surveying
  - Manual
- Video-log van

Datasets

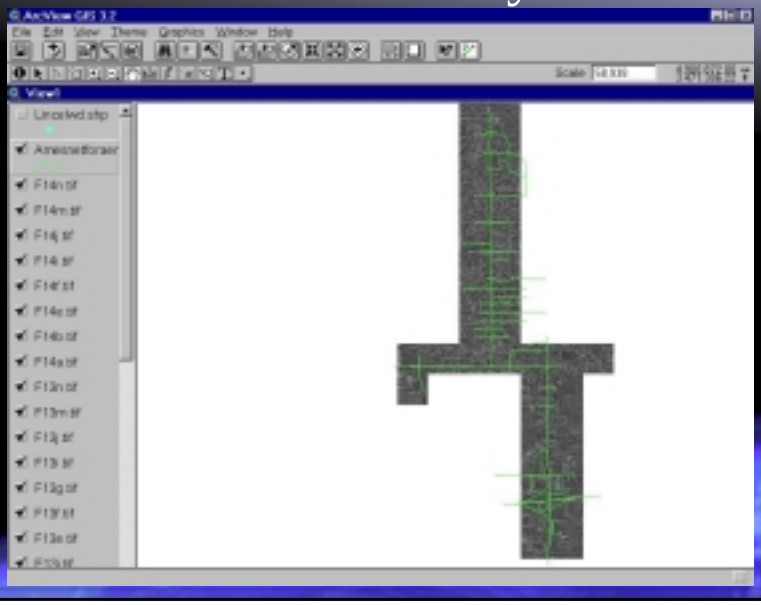
- 2-inch dataset - Georeferenced
- 6-inch dataset - Orthorectified
- 2-foot dataset – Orthorectified
- 1-meter dataset – Orthorectified

* not collected concurrently

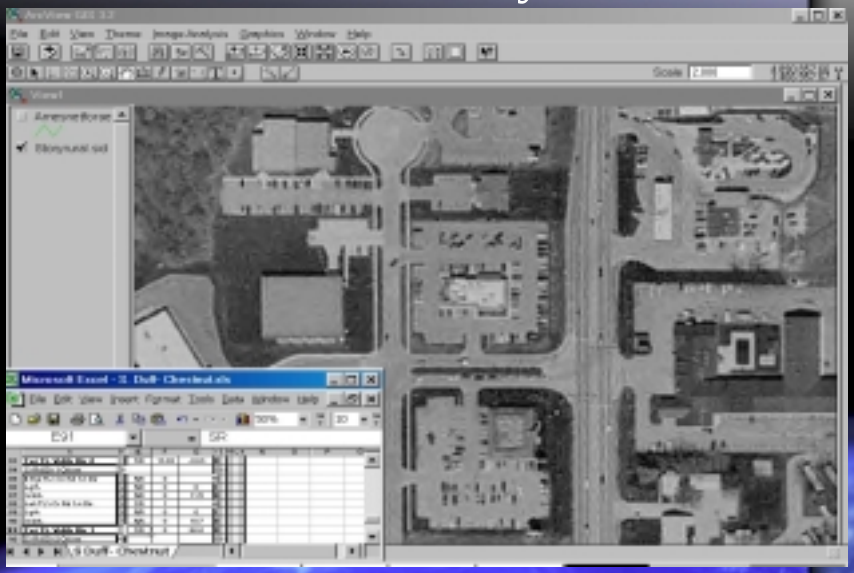
Pilot Study Locations



Extraction of Inventory Features



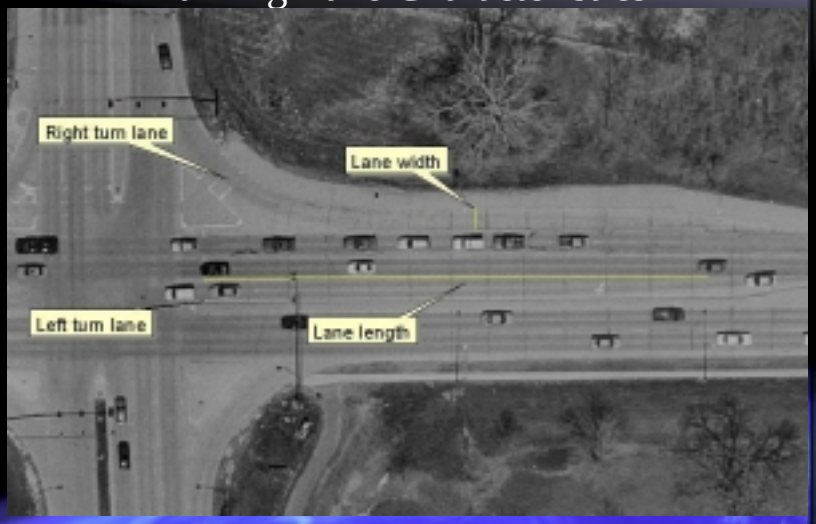
Extraction of Inventory Features



Extraction of features from 2 foot image

Extraction Procedures

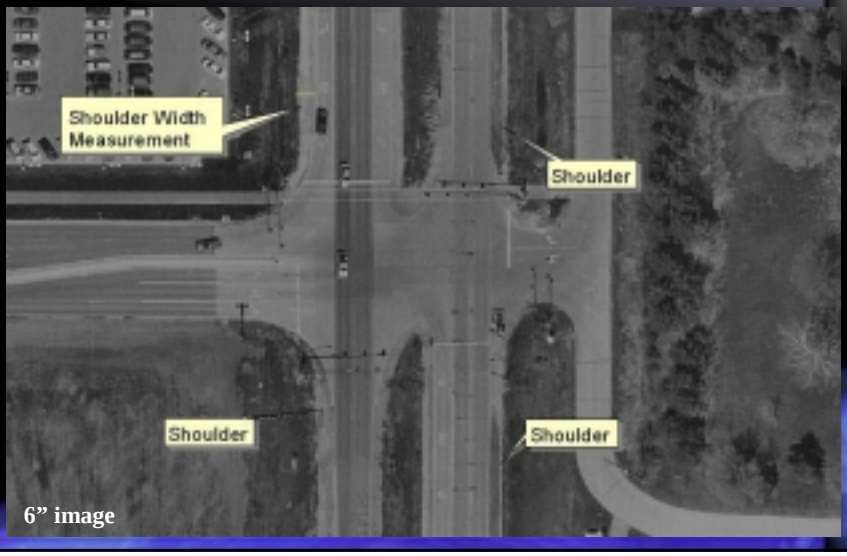
Turning Lane Characteristics



6" image

Extraction Procedures

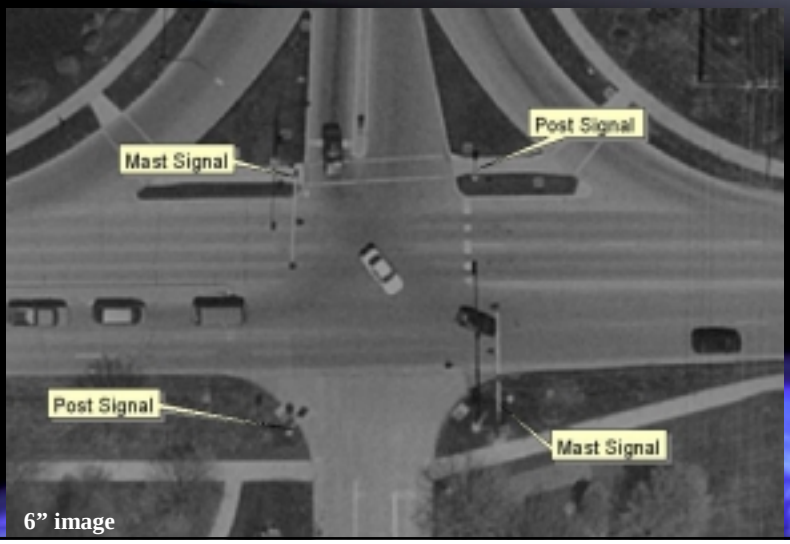
Shoulder Characteristics



6" image

Extraction Procedures

Signal Structure



6” image

Performance Measures

- Feature Identification
- Accuracy of Linear Measurements

Feature Identification

- Number of features identified in aerial photos versus ground truth
- e.g. only 44% of the time can correctly identify the number of through lanes (2' resolution)
- All shoulder edges can be identified with 6-inch resolution photos

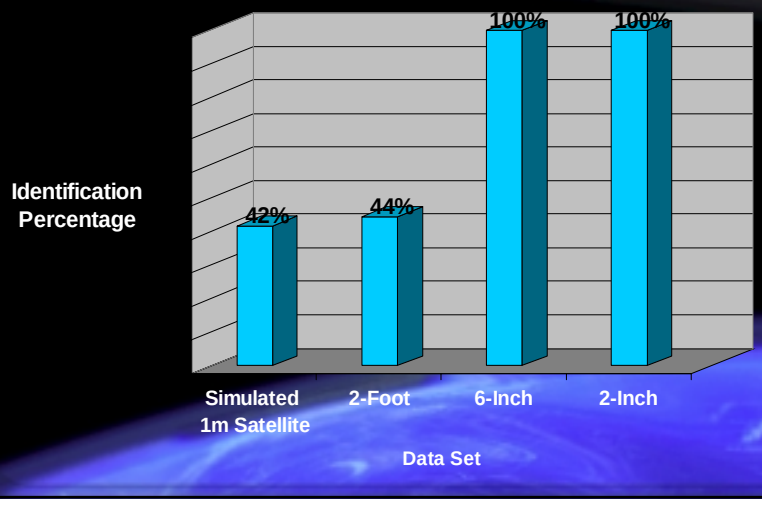
Feature Identification

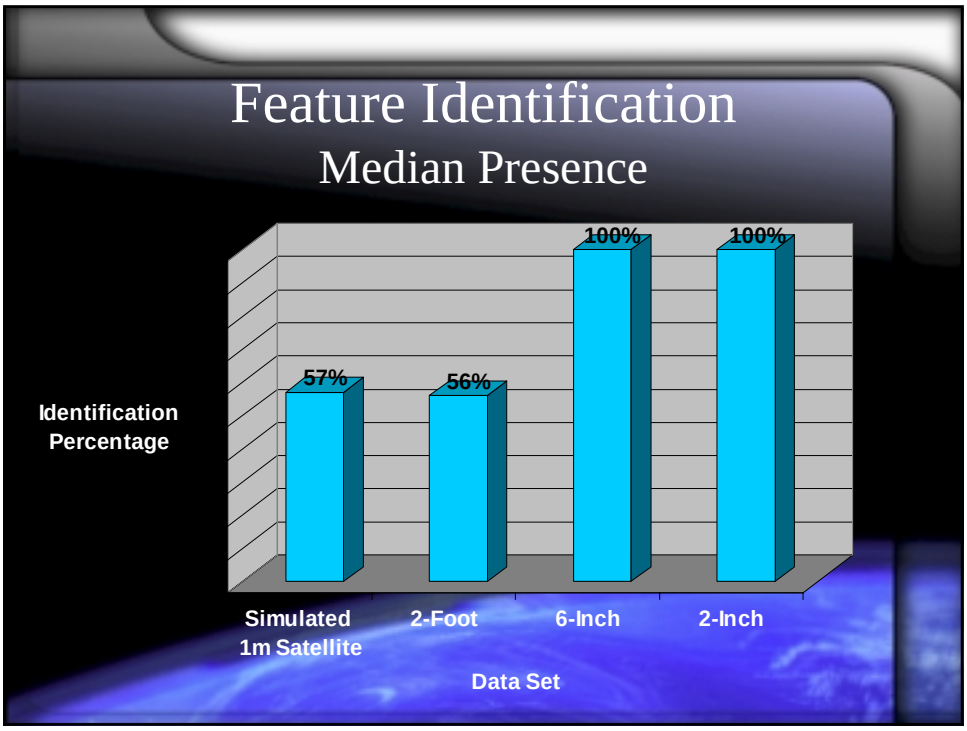
	Simulated 1m Satellite	2-Foot	6-inch	2-inch
Number of Through Lanes	42%	44%	100%	100%
Through Lane Width	<25%	<25%	100%	100%
Shoulder Presence/Type	N/A	30%	100%	100%
Shoulder Width	N/A	0%	100%	100%
Parking Presence/Type	83%	95%	100%	100%
Median Presence/Type	56%	57%	100%	100%
Median Width	56%	57%	100%	100%
Private Access	100%	100%	100%	100%
Comm/Ind Access	100%	100%	100%	100%
Pavement Type	0%	0%	85%	100%
Intersection Design	100%	100%	100%	100%
Land Use	100%	100%	100%	100%

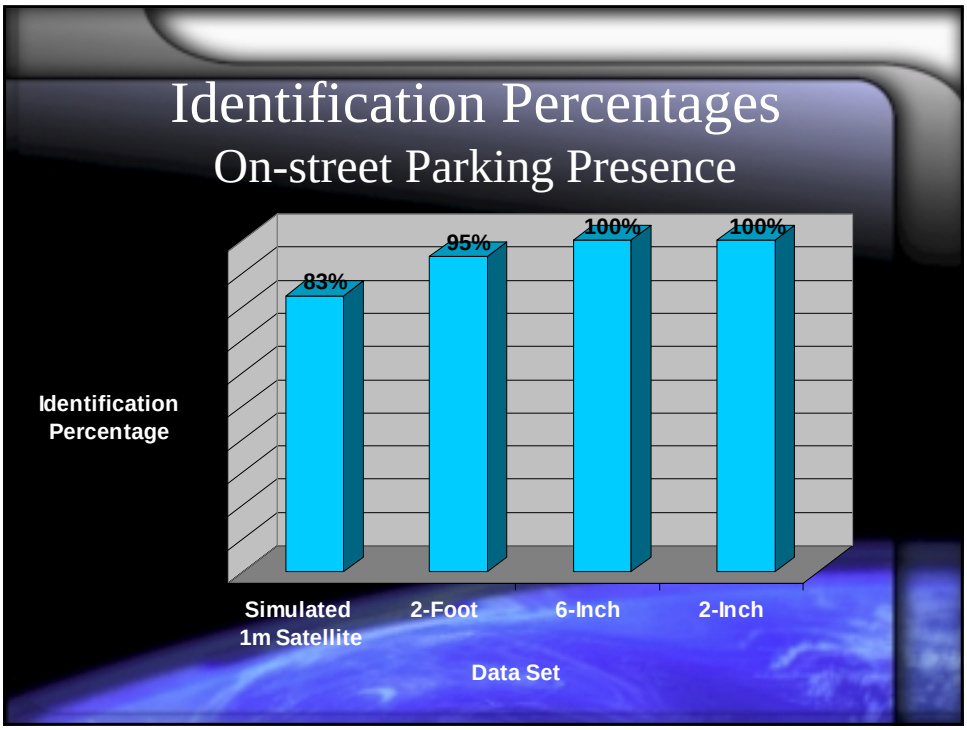
Feature Identification

	Simulated 1m Satellite	2-Foot	6-inch	2-inch
Crosswalks	0%	0%	100%	100%
Pedestrian Islands	<25%	<25%	100%	100%
Stop Bars	0%	<25%	100%	100%
Signal Structure/Type	0%	0%	90%	100%
Right Turn Lane Presence	71%	58%	100%	100%
Right Turn Lane Length	57%	58%	100%	100%
Right Turn Lane Width	57%	50%	100%	100%
Left Turn Lane Presence	63%	47%	100%	100%
Left Turn Lane Length	50%	47%	100%	100%
Left Turn Lane Width	50%	37%	100%	100%
Total Roadway Width	100%	100%	100%	100%

Feature Identification
Number of Through Lanes



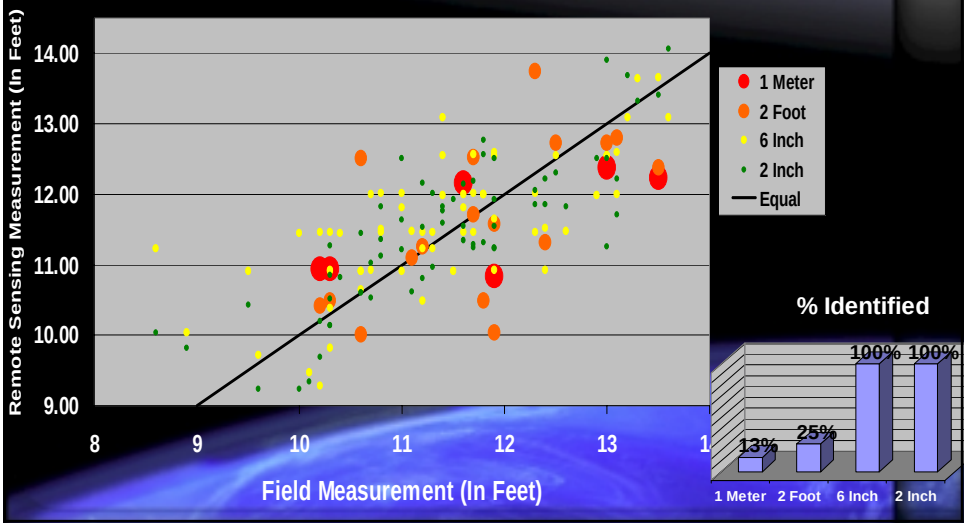

Feature Identification
Median Presence
Identification Percentage
57%
56%
100%
100%
Simulated 1m Satellite
2-Foot
6-Inch
2-Inch
Data Set

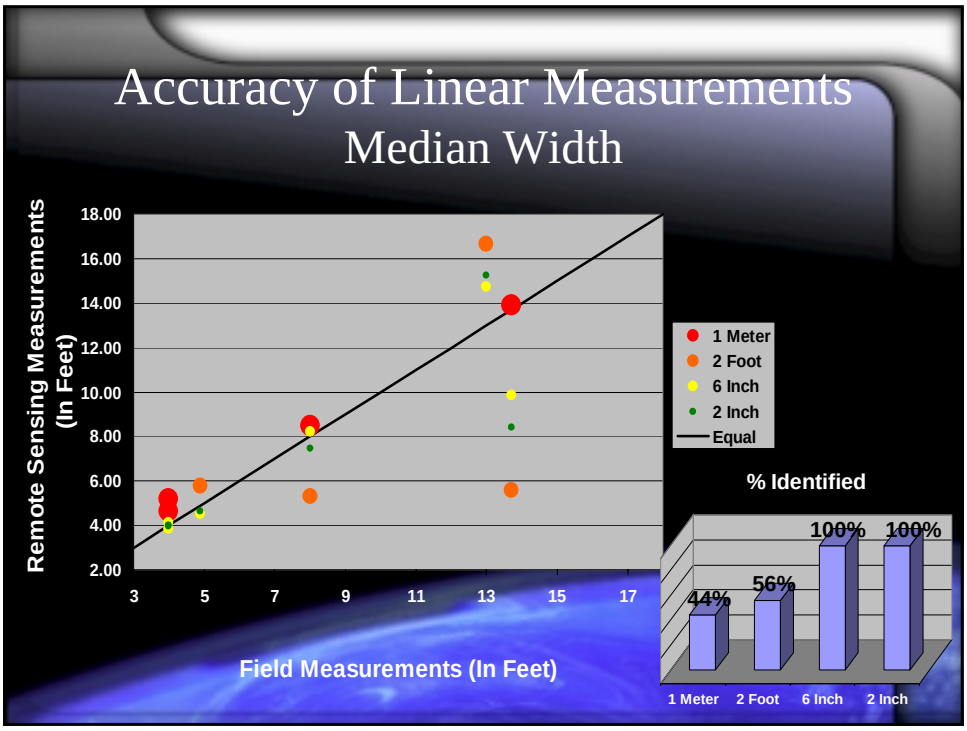

Identification Percentages
On-street Parking Presence
Identification Percentage
83%
95%
100%
100%
Simulated 1m Satellite
2-Foot
6-Inch
2-Inch
Data Set

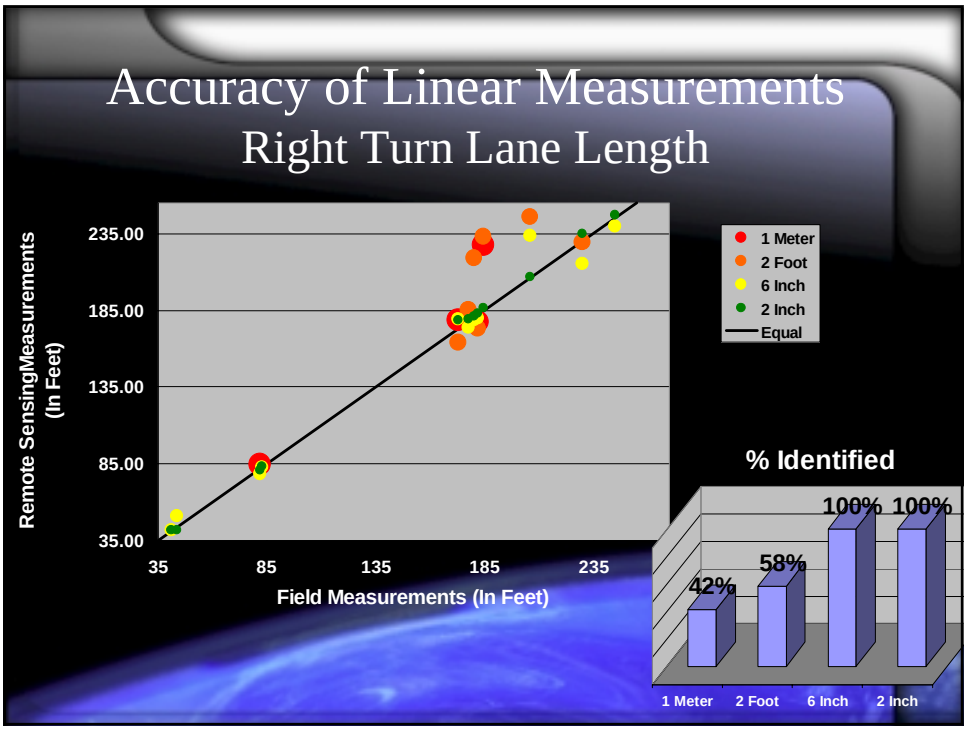
Accuracy of Linear Measurements

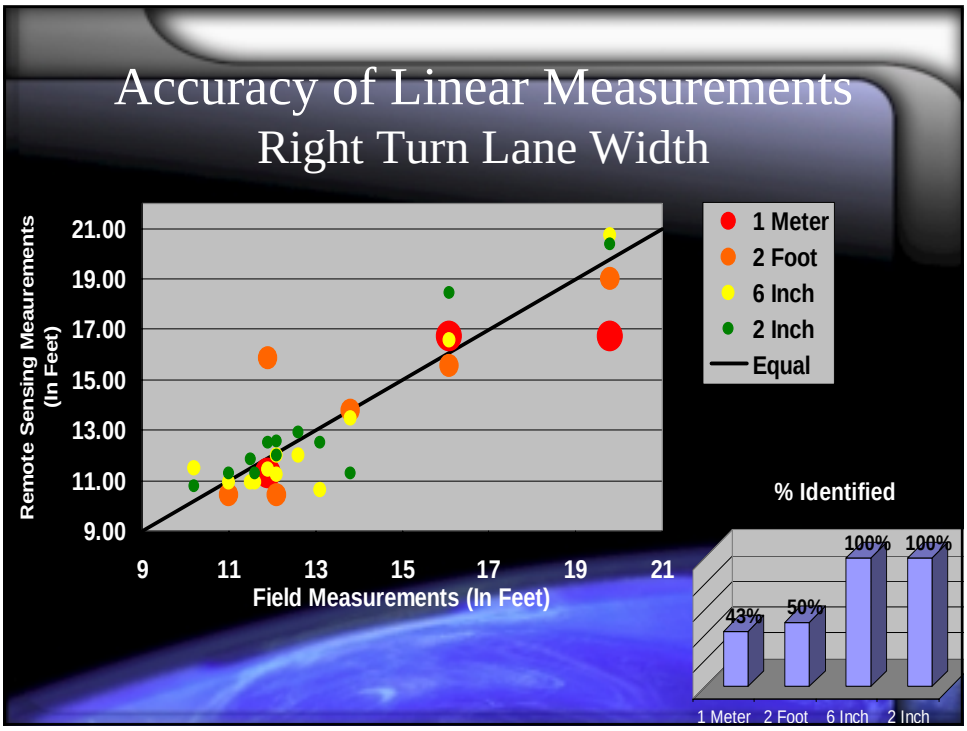
- Comparison of extracted measurements to ground truth
  - e.g. 37/67 measurements of individual through lane width were within 6 inches of the true measurement using 2-inch resolution photos
- Recommended accuracies
  - Lane lengths within ± 1 meter (± 3.28 feet)
  - Lane widths within ± .1 meter (± .328 feet)
  - Shoulder widths within ± 0.1 meter (± .328 feet)
  - Median widths within ± 0.1 meter (± .328 feet)

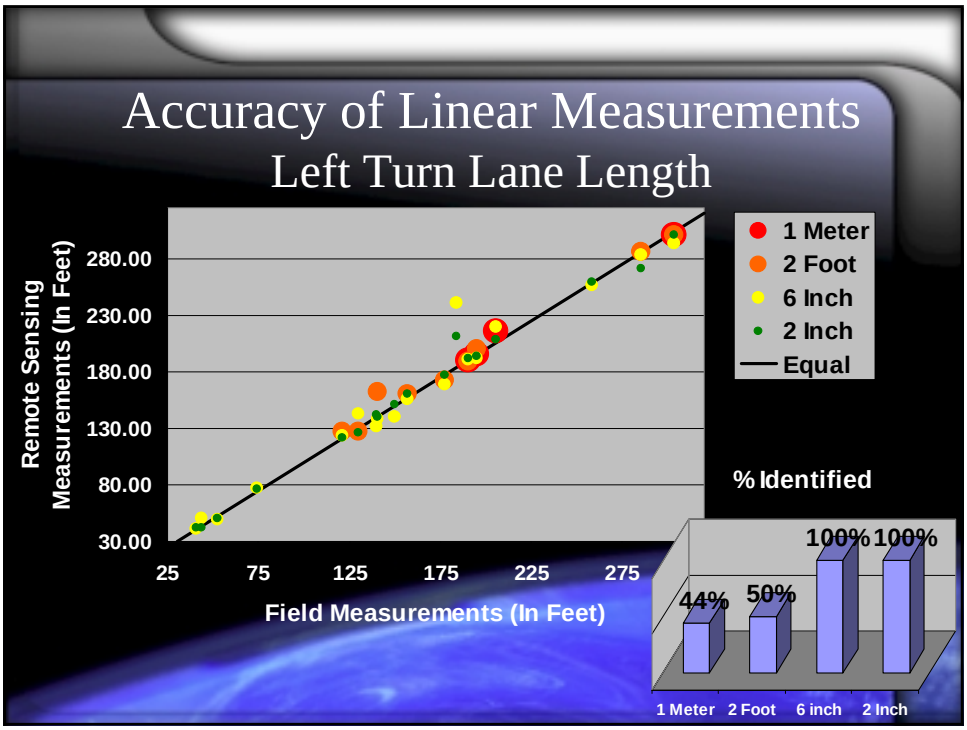
Accuracy of Linear Measurements Through Lane Width

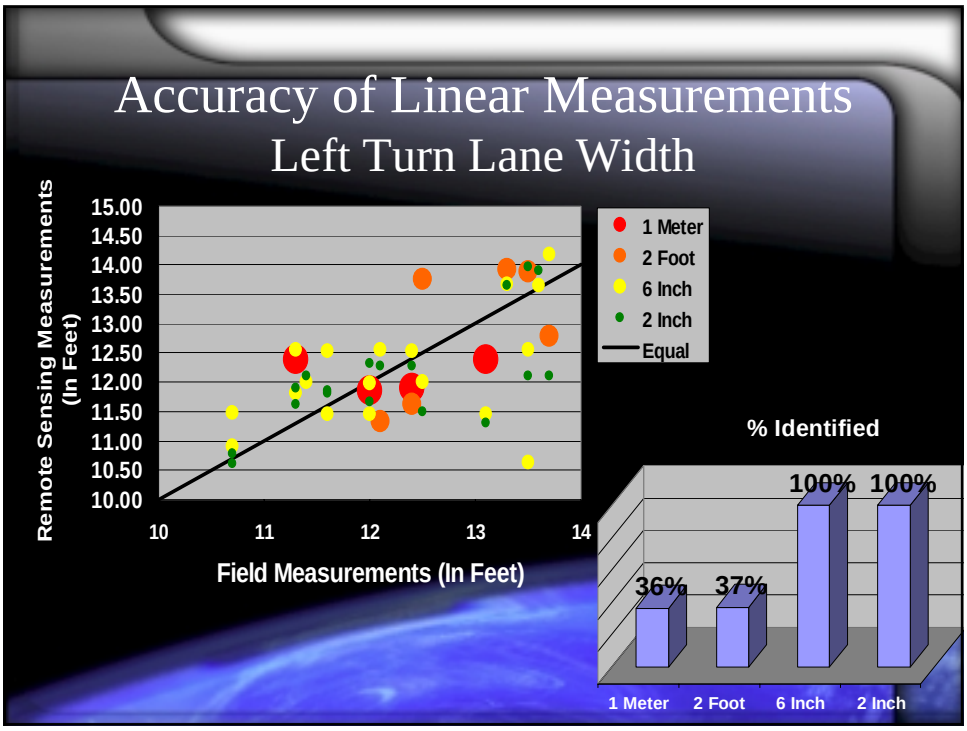


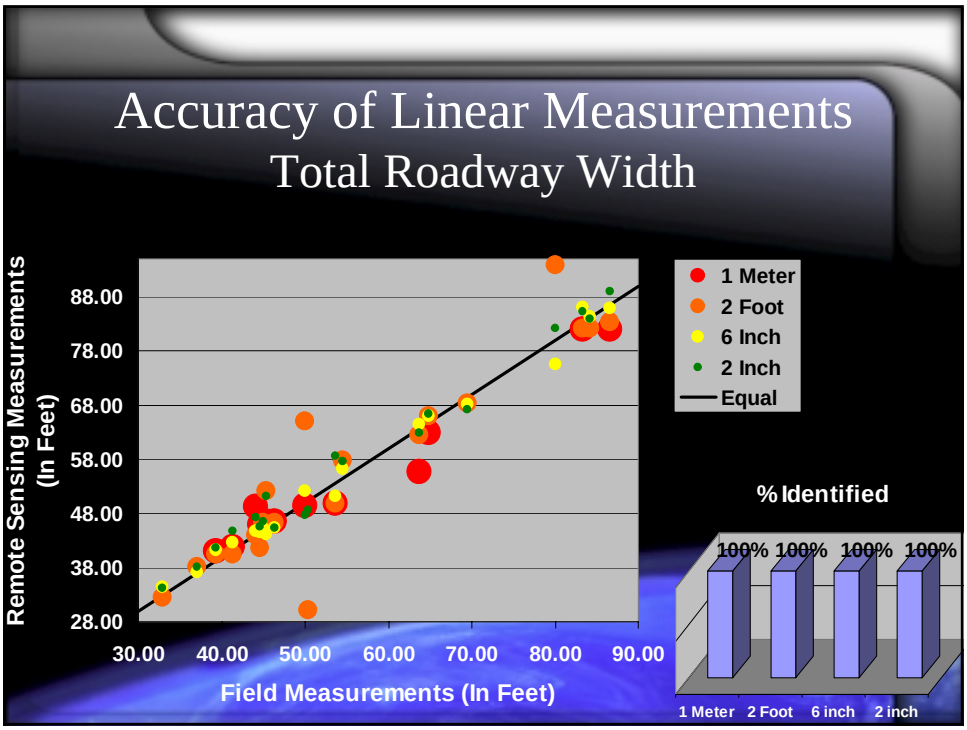

Accuracy of Linear Measurements
Median Width
Remote Sensing Measurements (In Feet)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
3
5
7
9
11
13
15
17
Field Measurements (In Feet)
1 Meter
2 Foot
6 Inch
2 Inch
Equal
% Identified
44%
56%
100%
100%
1 Meter
2 Foot
6 Inch
2 Inch


Accuracy of Linear Measurements
Right Turn Lane Length
Remote SensingMeasurements (In Feet)
235.00
185.00
135.00
85.00
35.00
35
85
135
185
235
Field Measurements (In Feet)
1 Meter
2 Foot
6 Inch
2 Inch
Equal
% Identified
42%
58%
100%
100%
1 Meter
2 Foot
6 Inch
2 Inch


Accuracy of Linear Measurements
Right Turn Lane Width
Remote Sensing Meaurements (In Feet)
21.00
19.00
17.00
15.00
13.00
11.00
9.00
9
11
13
15
17
19
21
Field Measurements (In Feet)
1 Meter
2 Foot
6 Inch
2 Inch
Equal
% Identified
43%
50%
100%
100%
1 Meter
2 Foot
6 Inch
2 Inch


Accuracy of Linear Measurements
Left Turn Lane Length
Remote Sensing Measurements (In Feet)
280.00
230.00
180.00
130.00
80.00
30.00
25
75
125
175
225
275
Field Measurements (In Feet)
1 Meter
2 Foot
6 Inch
2 Inch
Equal
% Identified
44%
50%
100%
100%
1 Meter
2 Foot
6 inch
2 Inch


Accuracy of Linear Measurements
Left Turn Lane Width
Remote Sensing Measurements (In Feet)
15.00
14.50
14.00
13.50
13.00
12.50
12.00
11.50
11.00
10.50
10.00
10
11
12
13
14
Field Measurements (In Feet)
1 Meter
2 Foot
6 Inch
2 Inch
Equal
% Identified
36%
37%
100%
100%
1 Meter
2 Foot
6 Inch
2 Inch


Accuracy of Linear Measurements
Total Roadway Width
Remote Sensing Measurements (In Feet)
88.00
78.00
68.00
58.00
48.00
38.00
28.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
Field Measurements (In Feet)
1 Meter
2 Foot
6 Inch
2 Inch
Equal
% Identified
100%
100%
100%
100%
1 Meter
2 Foot
6 inch
2 inch

Problems/Difficulties

- Different data sources
  - Taken on different days
  - Saved in different formats (.tif, .sid)
  - All sets are panchromatic, no color
- Potential photo errors
  - Atmospheric distortions
  - Camera displacements at time of exposure

Problems/Difficulties

- Vegetation can block the view of features
- Impossible to begin and end measurements on images at the same points as were used in the field
- Pavement markings heavily relied upon for length and width measurements, but these are not repainted in the exact location

Conclusions

- 1-meter and 2-foot images allow identification of
  - Intersection design (4-way, T, etc.)
  - Presence of on-street parking
  - Driveway location/land use
- 2-foot images also allow some identification of:
  - Number of thru lanes/lane width
  - Median presence
  - Turning lane presence/type/length/width

Conclusions

- 6-inch images allow more detailed data to be identified and extracted
  - Lane widths and lengths (through and turn lanes)
  - Shoulder presence/width
  - Signal structures

2-inch images allowed all elements to be identified and measured

Recommendations

- 1-meter and 2-foot images
  - Applicable for limited intersection inventories
    - Intersection Design/Alignment
    - Land Use
    - Parking identification
- 6-inch and 2-inch images
  - Applicable for detailed inventories
    - Widths, lengths
    - Feature types and number (pavement, signal)